

Humidity Sensitivity of Large Area Silicon Sensors: Study and Mitigation

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The production of large area sensors is one of the main challenges that the ATLAS collaboration faces for the new Inner-Tracker (ITk) full-silicon detector. During the prototype fabrication phase for the High Luminosity Large Hadron Collider (HL-LHC) upgrade, several ATLAS institutes observed indications of humidity sensitivity of large area sensors, even at relative humidities well below the dew formation. Specially, barrel and end-cap silicon strip sensors fabricated in 6-inch wafers manifest a prompt decrease of the breakdown voltage when operating under relative humidity above a threshold, adversely affecting the performance of the sensors.

This work presents an extensive study of this behavior on large area sensors. The locations of the hotspots at the breakdown voltage for different humidity levels are revealed using different infrared thermography techniques. Several palliative treatments are attempted, proving the influence of sensor cleaning methods or baking on the device performance, but no influence on the humidity sensitivity. Furthermore, an extensive study of the incidence of the sensitivity is presented, showing the time evolution and radiation influence. In addition to the investigation of these prototype sensors, a specific fabrication batch of large sensors with special passivation is also studied and complemented with simulations, allowing for a deeper understanding of the responsible mechanisms.

Finally, a summary of the actions to be taken during sensor production and assembly is derived from this work, in order to minimize the impact of humidity sensitivity on the performance of large area silicon sensors for High Energy Physics (HEP) experiments.

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